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Oil and Gas Technologies for the Arctic and Deepwater

Summary

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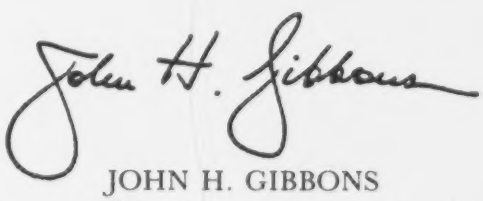
Foreword

Nearly 2 billion acres of offshore public domain is owned by the United States adjacent to Alaska and the lower 48 States. Much of the Nation's future domestic petroleum supply is expected to come from this area. Areas of highest potential apparently occur in deeper water and in the Arctic where operating conditions are severe, development costs high, and financial risks immense. As the pace of exploration increases in these "frontier" regions, questions arise about the technologies needed to safely and efficiently explore and develop oil and gas in harsh environments.

The Office of Technology Assessment undertook this assessment at the joint request of the House Committees on Interior and Insular Affairs and on Merchant Marine and Fisheries. The study explores the range of technologies required for exploration and development of offshore energy resources and assesses associated economic factors and financial risks. It also evaluates the environmental factors related to energy activities in frontier regions and considers important government regulatory and service programs.

In March 1985, the Secretary of the Interior announced the Administration's proposed new 5-year offshore leasing program that will determine the pace of oil and gas exploration in Federal offshore waters through 1991. The proposed leasing schedule will be under review by the 99th Congress, with final approval slated for the Summer of 1986. OTA's report on Arctic and deepwater oil and gas is intended to provide a timely and useful reference for the Congress as it reflects on the Department of the Interior's proposed program.

OTA is grateful to the Offshore Technologies Advisory Panel and participants in OTA's workshops for their help in the assessment. Splendid cooperation was received from a number of executive agencies during the course of the study, including the Minerals Management Service, National Oceanic and Atmospheric Administration, and the U.S. Coast Guard. Special thanks go to the Arctic Environmental Information and Data Center of the University of Alaska and its Director, David Hickok, for field assistance to OTA in Alaska.



JOHN H. GIBBONS
Director

Oil and Gas Technologies for the Arctic and Deepwater Advisory Panel

Dr. John H. Steele, *Chairman*
Director, Woods Hole Oceanographic Institute

Jacob Adams
President
Arctic Slope Regional Corp.

Larry N. Bell
Vice President
Arco Oil & Gas Co.

Charles L. Blackburn
Executive Vice President
Exploration and Development
Shell Oil Co.

Sarah Chasis
Senior Staff Attorney
Natural Resources Defense Council

Clifton E. Curtis
Executive Vice President
The Oceanic Society

Gordon Duffy
Secretary, Environmental Affairs
State of California

Walter R. Eckelmann
Senior Vice President
Sohio Petroleum Corp.

William Fisher
State Geologist
State of Texas

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Associate Director for Governmental Coordination
Office of the Governor of Alaska

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Dan R. Motyka
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Stanley Stiansen
Vice President
American Bureau of Shipping

Wallace Tyner
Professor
Purdue University

Michael T. Welch
Vice President
Citibank, N.A.

*Represented C. Robert Palmer at panel meetings.
**Represented Clifton E. Curtis at panel meetings.

OTA Project Staff—Oil and Gas Technologies for the Arctic and Deepwater

John Andelin, *Assistant Director, OTA*
Science, Information, and Natural Resources Division

Robert W. Niblock, *Oceans and Environment Program Manager*

Project Staff

James W. Curlin, *Project Director*

Peter Johnson, *Senior Associate*

Cheryl Dybas Nan Harllee Daniel Kevin

Candice Stevens William Westermeyer

Administrative Staff

Kathleen A. Beil Jacquelynne R. Mulder Kay Patteson

Contributing Staff

Richard Rowberg, *Program Manager, Energy and Materials Program*

Jenifer Robison, *Energy and Materials Program*

Dennis Dobbins, *Health Program*

Contractors/Consultants

Edward Horton, Deep Oil Technology
Virgil Keith, ECO
Francois Lampietti
Leslie Marcus
Peter Noble, Marine Technology Corp.
Denzil Pauli
Robert Schulze
Dr. James Smith, University of Houston
Robert Visser, Belmar Engineering

Oil and Gas Technologies for the Arctic and Deepwater

INTRODUCTION

This assessment addresses the technologies, the economics, and the operational and environmental factors affecting the exploration and development of energy resources in the deepwater and Arctic regions of the U.S. Outer Continental Shelf (OCS) and the 200-mile Exclusive Economic Zone (EEZ) established in March 1983. For the purposes of this study, OTA defined "deepwater" as those offshore areas where water depths exceed 400 meters or 1,320 feet. The "Arctic" is defined as the Beaufort, Chukchi, and Bering Seas north of the Aleutian Islands.

Leasing submerged coastal lands for oil and gas development began with State programs in California, Louisiana, and Texas years before there was a Federal offshore leasing program. Leasing in Federal offshore lands began in 1954 after the OCS Lands Act of 1953 provided the Secretary of the Interior guidance and authority for such activity. The industry leased, explored, and developed OCS oil and gas under the provisions of the 1953 Act for 25 years. Most of the offshore activity during that period was in the Gulf of Mexico and the Pacific Ocean off southern California. Then, in 1978, an emerging national awareness of the environment coupled with the Arab oil embargo and increased concern about energy supplies led to enactment of the OCS Lands Act Amendments.

Congress included in the 1978 amendments a directive that the Secretary of the Interior seek a balance in the OCS leasing program that would accommodate "expeditious" development while protecting the environment and the interests of the coastal States. The amendments established procedures for considering environmental and State concerns in leasing decisions, required the orderly formulation of future leasing schedules, and ordered experimentation with a variety of alternative bidding systems. In seeking to balance energy development and other values, the offshore leasing program has been the target of criticism from coastal States, environmentalists, and the industry. These criticisms have sharpened in the 1980s as offshore activities have expanded into the deepwater and Arctic frontier areas.

The revised leasing system mandated by the 1978 amendments has been in place slightly more than 6 years. In this time, there have been numerous legal challenges to the leasing program, changes in leadership and reorganizations at the Department of the Interior, and a shift in leasing from nearshore areas to offshore frontier regions. In spite of the fact that it has proven to be one of the government's most controversial natural resource programs, the offshore leasing program has generally performed well in achieving the objectives set by Congress. It is unlikely that any statutory framework devised to expand and expedite exploration for oil and gas on Federal lands, while giving equal weight to protecting the environment and honoring the sovereign goals of the States, can be anything but adversarial and contentious. Despite the conflicts which have arisen, leasing of offshore oil and gas has worked more smoothly and efficiently than other Federal energy leasing programs.

The existing OCS Lands Act appears to provide Congress and the executive branch sufficient latitude to guide the leasing program in any direction that public policy may dictate. In general, the OCS Lands Act allows the administrative flexibility needed to adjust leasing terms and conditions to deepwater and Arctic frontier areas.

OFFSHORE RESOURCES AND FUTURE ENERGY NEEDS

The current abundance of oil and gas in the world market is considered to be a temporary anomaly. As economic recovery and cheaper energy stimulates consumption in the United States, the Nation will be faced with increasing petroleum imports unless substantial new domestic reserves are discovered. Oil imports, which have declined in recent years, are expected to gradually rise and may again reach the high levels of the 1970s.

Forecasts by the Department of Energy and the Gas Research Institute indicate domestic energy shortfalls may necessitate oil imports of about 7 million barrels per day and natural gas imports of about 3 trillion cubic feet per day by the end of the century. Forecasts by OTA and the Congressional Research Service anticipate higher oil import rates in the 1990s, perhaps again reaching the historic 1977 high of 9.3 million barrels per day. Predictions of declining real oil prices in the short term, which would reduce incentives for exploration and production of domestic resources, make even these forecasts optimistic. Oil imports of the magnitude expected in the 1990s would make

the country vulnerable to supply interruptions and would increase the trade deficit.

Where will new domestic oil and gas resources be found to meet future U.S. energy needs? The onshore areas of the lower 48 States are the most densely explored and developed oil provinces in the world. But—with the exception of Prudhoe Bay, the largest field in North America—few sizable onshore discoveries have come on line in the past decade. Domestic reserves continue to dwindle. It is unlikely—but not impossible—that a giant field similar to Prudhoe Bay will be found onshore in the lower 48 States.

Most of the undiscovered oil and gas in the United States is expected to be in offshore areas or onshore Alaska. But resource estimates of undiscovered oil and gas, while useful as indicators of relative potential, are little more than educated guesses. Experts agree that prospects for oil and gas offshore are good, but they also admit there is a chance that only an insignificant amount of oil and gas may be found. In fact, only one major offshore field of a size needed to significantly increase reserves—the Point Arguello Field off southern California—has been discovered since offshore exploration was accelerated in the 1970s.

Exploration in the offshore frontier regions during the last 5 years has yielded some information—most of it negative—about potential oil and gas resources. In 1981, the U.S. Geological Survey (USGS) estimated that between 26 and 41 percent of the future oil and between 25 and 30 percent of the future natural gas was offshore. However, the Minerals Management Service (MMS) recently lowered the estimates of undiscovered recoverable offshore oil by half and of natural gas by 44 percent as a result of unsuccessful exploration efforts in Alaska and the Atlantic (see table 1).

Much of the 1.9 billion acres within the offshore jurisdiction of the United States is still unexplored. Only actual exploratory drilling can determine the presence of hydrocarbons. The offshore oil and gas industry will drill the most promising geological structures as exploration expands in the Arctic and deepwater frontiers. If significant reserves are not discovered in the first round of drilling, the government may need to consider a "second-round" leasing strategy to induce the industry to drill second-level prospective structures.

If Congress wishes to pursue the objectives of the OCS Lands Act, it is important that the oil and gas industry have access to Federal offshore lands to more accurately determine the resource potential of frontier areas. A "second-round" leasing strategy may also be needed to assess the extent of smaller offshore reservoirs that could cumulatively contribute to the Nation's energy security.

Table 1.—Revised Offshore Oil and Gas Resource Estimates

Planning area	Oil (billion barrels) 1981	1985	% change	Gas (trillion cubic fee) 1981	1985	% change
Alaska:						
Beaufort Sea	7.8	0.89		39.3	3.93	
Navarin Basin	1.0	1.30		1.30	1.58	
Chukchi Seal	1.6	0.54		13.8	3.02	
St. George Basin	0.4	0.37		2.5	3.47	
Norton Basin	0.2	0.09		1.2	0.43	
Other	1.2	0.11		2.2	1.42	
Total Alaska	12.2	3.30	−73	64.6	13.85	−78
Atlantic:						
North Atlantic	1.4	3.30		5.6	2.14	
Mid-Atlantic	3.1	0.35		14.2	6.02	
South Atlantic	0.9	0.22		3.6	4.04	
Other	—	—		0.3	0.11	
Total Atlantic	5.4	0.68	−87	23.7	12.31	−48
Gulf of Mexico:						
Western Gulf	5.2	1.90		65.7	26.76	
Central Gulf	—	3.72		—	30.69	
Easter Gulf	1.0	0.41		2.8	2.19	
Total Gulf of Mexico	6.2	6.03	− 3	68.2	59.64	−13
Pacific:						
Northern California	0.5	0.25		0.9	1.12	
Southern California	2.4	1.54		3.9	2.42	
Central California	—	0.36		—	0.51	
Washington and Oregon	0.3	0.04		1.4	0.65	
Total Pacific	3.2	2.19	−31	6.2	4.70	−24
Total offshore	27.0	12.2	−55	162.7	90.5	−44

SOURCE: U.S. Geological Survey, Circular 860, *Estimates of Undiscovered Recoverable Conventional Resources of Oil and Gas in the United States* (1981). Minerals Management Service, *Estimates of Undiscovered Oil and Gas Resources for the Outer Continental Shelf* (Personal correspondence, Feb. 4, 1985).

TECHNOLOGIES FOR ARCTIC AND DEEPWATER AREAS

Developing oil and gas in the deepwater and Arctic frontiers will be a major technological challenge. The severe environments and remote locations will require the design and construction of innovative and costly exploration and production systems. **The key to safe, efficient, and economical development of offshore resources in these frontiers will be the technology used for exploring, producing, and transporting oil and gas under extreme environmental conditions.**

Offshore technology has generally developed—and will probably continue to develop—in an evolutionary fashion. Once wholly landbased, the oil and gas industry has moved its onshore technology offshore, first onto piers, then onto seabed-bound platforms, and finally onto floating vessels as it ventured into deeper water.

Exploration systems have been operating in many deepwater and Arctic areas for several years. But production systems have not yet been installed in frontier areas. Several production systems have been designed, however, and some have been tested in prototype. In addition, many of the individual components that make up total production systems are in service elsewhere in the world. The systems finally adapted for use in the deepwater and Arctic frontiers will be a combination of previously tested subsystems and new components designed to withstand specific and often severe conditions.

The industry may be characterized as cautiously conservative in its approach to designing and deploying new technology. **Yet, in general, it appears that development of offshore technology is progressing at a pace compatible with government leasing schedules and projected exploration and development timeframes.**

Arctic Technologies

The severity of the Arctic environment generally dictates a rigorous approach to design and construction of all primary and support systems. The cold temperatures, ice, harsh weather, and remoteness of many Arctic regions will force the use of costly equipment to achieve required reliability.

Technology for meeting the challenges of the Arctic will have to develop concurrently with exploration for oil and gas. Because of the immense costs of development in this hostile environment, there is a tremendous incentive for industry to design and build using advanced technologies and materials that will ensure reliability and cost effec-

Photo credit: SEDCO

First mobile offshore drilling unit in U.S. Beaufort Sea—Exxon's Super CIDS.

tiveness. This is particularly true for production systems which, unlike exploration equipment, must withstand the severe, exposed, and corrosive conditions for the life of the field—usually 20 years or more.

In order to assess the technology needed to explore, develop, and produce oil and gas in the Arctic, OTA studied hypothetical sites at Harrison Bay in the Beaufort Sea, the Norton Basin in the Bering Sea, and the Navarin Basin in the Bering Sea (see box). Each of the three Arctic scenarios was based on different assumptions of environmental conditions, water depths, oil field sizes, and production rates, which consequently call for different technologies. Study of the OTA scenarios and review of available industry and government Arctic research and development programs indicate that priority should be given to addi-

Arctic Technology Scenarios

To assess Arctic oil and gas technologies, OTA selected hypothetical prospects in three Arctic areas with differing environments and operating conditions. The scenarios are in the Harrison Bay area of the Diapir Field, the Norton Basin, and the Navarin Basin. The assumptions made about field and operating conditions and technology requirements are only illustrative, and actual conditions may vary substantially from these scenarios.

Schedules and Costs.—The scenario schedules begin with the lease sale and end with peak production, a time span ranging from 11 years in the Norton Basin to almost 15 years in Harrison Bay. First production is assumed to begin 9 to 12 years after the lease sale. These schedules are probably optimistic because they assume the minimum time necessary to obtain necessary government approvals and also that production facilities are designed concurrently with permitting and approval.

OTA estimated the total costs of exploratory drilling to range from $435 to $825 million in the three Arctic scenarios. Total capital costs for development of the prospects are estimated to range from $2 to $11 billion, including the cost of drilling development wells, obtaining equipment, and building islands or platforms. Annual operating costs are estimated to range from about $100 million per year in the Norton Basin to $240 million per year in the Navarin Basin.

Exploration Technology.—The type of exploratory drilling rig used is largely determined by environmental conditions. In the Navarin Basin, which has the most severe winds and waves of all the Arctic planning areas, a semi-submersible drilling unit would be required. These drilling units, which maintain their position with anchors where bottom conditions are suitable or with dynamic positioning equipment, are the most stable platforms under severe weather conditions. Semi-submersibles have been used successfully in the North Sea and offshore eastern Canada.

In Harrison Bay, which has some moving pack ice, a gravel island would be used with reinforcing sandbags protecting against the erosive action of water and ice. In 50 feet of water, this island would be 300 to 400 feet in diameter at the top with a gradual slope to the seafloor base diameter of approximately 1,000 feet. Alternatives to the gravel island platform include mobile structures such as the CIDs concrete island drilling system now in use in the Beaufort Sea.

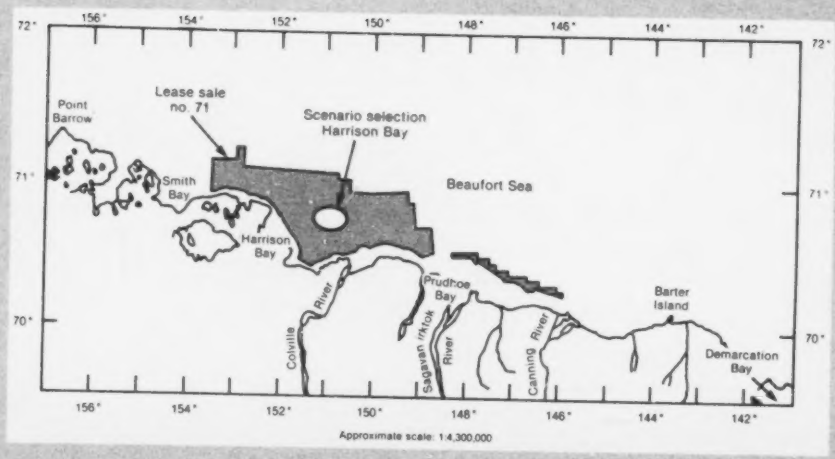
Despite dynamic ice movements in Norton Basin, open water season is usually long enough to permit exploratory drilling from a jackup rig. The operation would be similar to those using jackups in the North Sea or off the coast of eastern Canada.

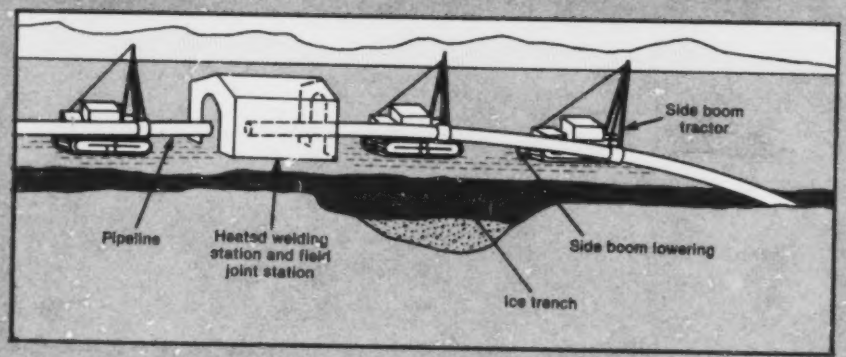
Development Technology.—Technology for Arctic field development is also determined by environmental conditions, as well as by the size of the field. Design requirements for production structures are more stringent than those for exploration due to the larger investment in wells and the longer service life of the equipment.

In the Harrison Bay and Norton Basin scenarios, gravel islands are used for field development. However, large gravel islands may become prohibitively expensive as water depth increases beyond 50 or 60 feet. One alternative is bottom-founded gravity structures similar to those used for exploratory platforms in the Beaufort Sea. In the Navarin Basin scenario, a gravity platform is used for development. Oil is treated on the islands or platform and stored in either onshore or offshore storage tanks (Harrison Bay and Norton Basin) or in gravity structures (Navarin Basin).

Transportation and Infrastructure.—Selection of Arctic transportation systems is influenced by the markets to be served, the size of the field, and the availability of capacity in the Trans-Alaskan Pipeline System (TAPS). Production from Harrison Bay is assumed to be transferred by pipeline to shore and then through TAPS. Offshore pipelines must be buried deep enough to avoid ice keel gouging and have adequate permafrost protection. The Norton Basin and Navarin Basin transportation modes involve transshipment terminals and icebreaking tankers, although these are only economical at high production rates.

A primary consideration in designing infrastructure and support services is the distance of the field from established onshore bases. Established facilities at Prudhoe Bay provide basic infrastructure support for the Harrison Bay scenario. However, the high transportation costs of this service may require a satellite base closer to the development site. Either Nome, which plans to build a deepwater harbor, or Dutch Harbor could be used as the support base for the Norton Basin scenario. Dutch Harbor is too far from Navarin Basin, which is the most remote of the scenarios, to be the sole support base. A forward base would have to be established on either St. Paul Island or St. Matthew Island; however, the latter is currently a wildlife refuge.





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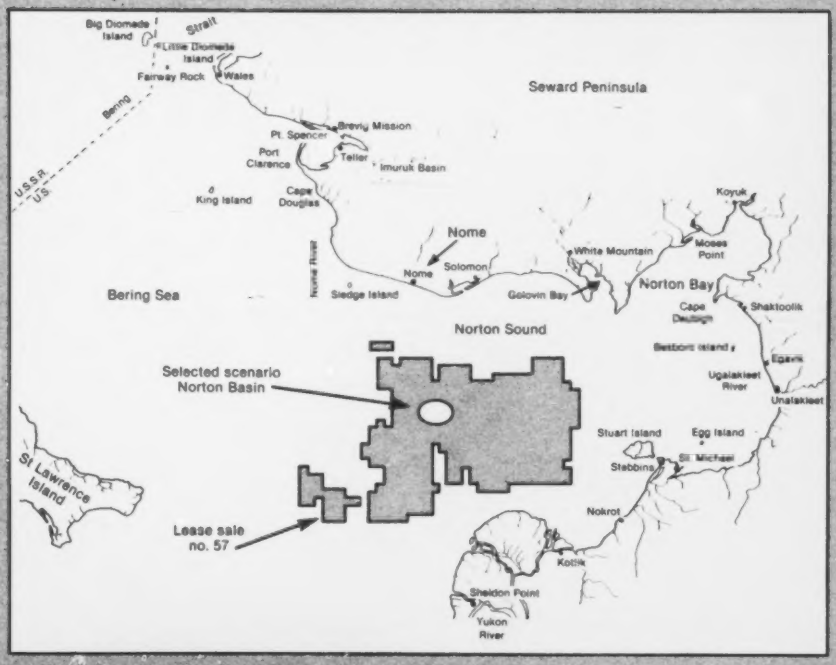

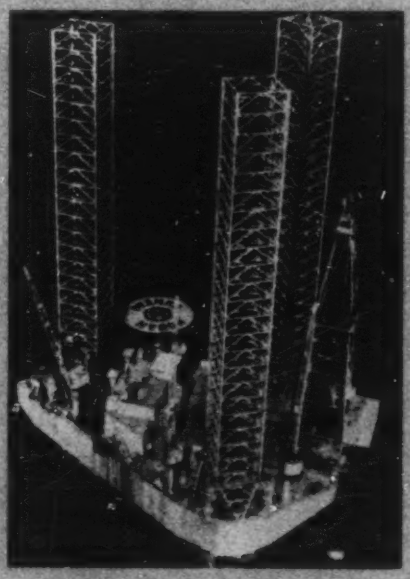

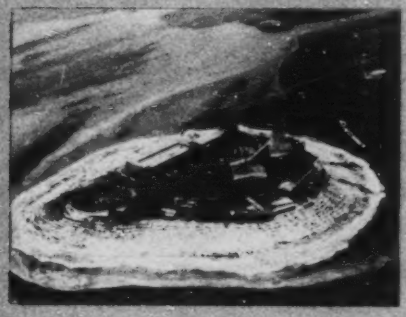

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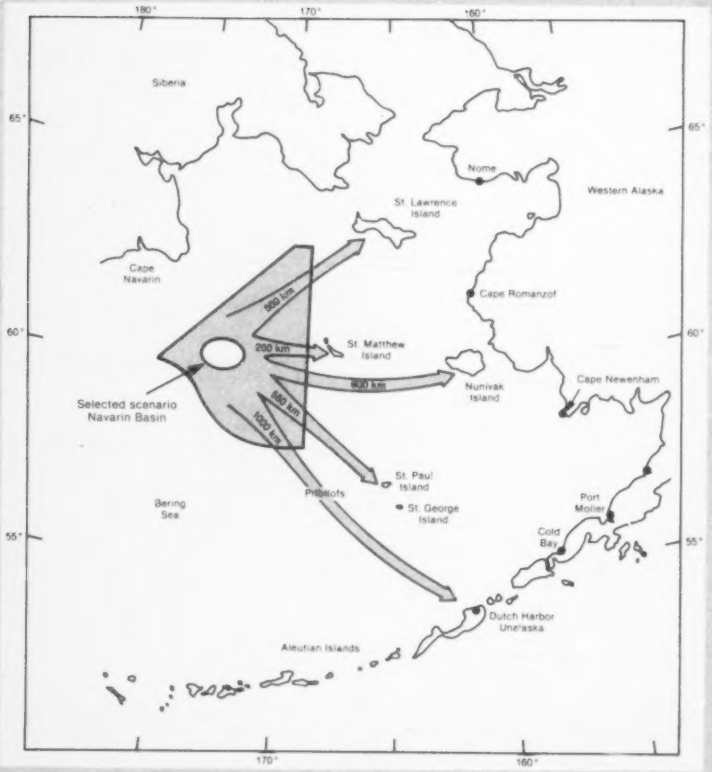

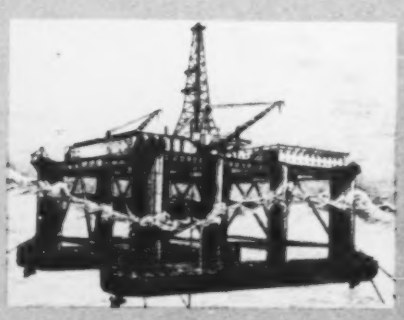

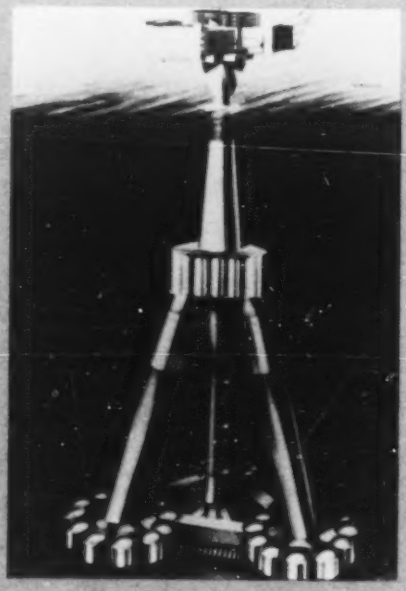

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tional research related to ice properties, ice movements and forces, oceanographic and meteorological processes, and seismicity.

Sea ice is considered to be the most important design factor for engineering in the Beaufort, Chukchi, and northern reaches of the Bering Seas. Additional research is needed to obtain basic data on ice strength, ice forces due to movements, and ice properties under the range of conditions likely to be encountered. Better surveillance of ice movements from satellites and aircraft could provide more accurate and up-to-date data. Additional research and development may be warranted on more rapid and effective trenching techniques to bury subsea pipelines below ice-gouge depths. The construction of icebreaking tankers that are capable of working year round in the Beaufort and Chukchi Seas will require better design data. For the St. George and North Aleutian Basins, more information is needed on seismic activities associated with the subduction of the Pacific plate beneath the North American plate.

Deepwater Technologies

Deepwater technologies must be developed to withstand such environmental factors as water currents, seafloor instability, mud slides, and hurricane-force winds and waves. In the U.S. OCS, there has been a natural progression of offshore technology from shallow water into ever-increasing depths. As the severity of the operating environment has increased, incremental modifications have been made to basic designs to deal with these changing factors. In general, as depths have increased, structures have become larger, more substantial, and consequently, more expensive. To assist in understanding the technology needed to explore, develop, and produce oil in the deepwater frontiers, OTA studied a hypothetical site off the central California coast in water depths of up to 4,100 feet (see box).

Exploratory drilling in very deep water is limited by extreme ocean waves and currents and subsea formation conditions which make drilling slow and difficult. To date, the deepest offshore exploration well was drilled in 6,952 feet of water in the Atlantic offshore region in 1984. The Department of the Interior is now offering leases in 7,500 feet in the Atlantic and up to 10,000 feet in the Pacific.

The deepest water from which oil is currently being produced is 1,025 feet in the Gulf of Mexico. Discoveries have been made in 1,640 feet of water in the Gulf of Mexico, but production systems are only now being developed. In the Mediterranean Sea, development wells have been drilled in 2,500 feet of water, but production has not yet begun.

Deepwater Technology Scenario

To assess deepwater oil and gas technologies, OTA selected a hypothetical prospect located offshore the central California coast approximately 38 miles west of Point Conception in water depths of 3,000 to 4,100 feet. The assumptions made about field and operating conditions and technology requirements are only illustrative, and actual conditions may vary substantially from this scenario.

Schedule and Costs.—The scenario schedule begins with the lease sale and ends with the completion of development drilling—a total of 13 to 14 years. First production is assumed to occur 10 years from the lease sale date. This schedule is probably optimistic because it assumes the minimum time necessary to obtain necessary governmental approvals. It also assumes that detailed design of the production platform will begin at the time of discovery and proceed concurrently with permitting and approval. Timeframes would also increase if the area is more difficult to develop than postulated, if a heavier or sour crude were discovered, or if two platforms were required rather than one.

Single exploratory wells are estimated to cost an average of $27 million in the deepwater scenario, and total exploration costs equal about $400 million. Development costs for the 300-million-barrel field, including the cost of the platform and the development wells, are estimated at $900 million. Operating costs are estimated at $25 million per year.

Exploration and Development Technology.—Exploratory drilling in the water depths assumed in the scenario is now within the capability of the industry. Several dynamically positioned drilling units, ship-shape and semi-submersible, are able to drill exploratory wells in water depths of 6,000 to 7,500 feet. The use of dynamic positioning equipment, which uses thrusters and acoustic signals to keep drilling units in place, has made these units independent of the constraints imposed by a mooring system.

Development of a discovery in water depths of 3,000 to 6,000 feet appears to be technically feasible but has not yet been achieved. Several development methods are possible, including tension leg platforms, floating production systems, and subsea production systems. A tension leg platform with surface completed wells has been selected for this scenario. Sixty directional wells would be drilled from the tension leg platform. They would have individual conductors from the ocean bottom to the lower platform deck for completion and hookup similar to methods used in fixed, bottom-founded platforms. Tension leg platforms have been designed for, although not yet deployed in, water depths up to 3,000 feet.

Transportation and Infrastructure.—The State of California prefers transport of oil to shore by subsea pipeline rather than shuttle tankers, primarily for environmental reasons. In the scenario, a tensioned 20-inch pipeline riser would be installed between the ocean floor template and the platform deck. The pipeline would be connected to the riser through a pull-in assembly. The technology, but not the actual equipment, exists to install a 20-inch pipeline in water depths of 7,500 to 10,000 feet. To date, pipeline installation has been limited to water depths of about 2,000 feet.

This scenario assumes that all production would be treated to pipeline quality on the platform, involving the installation of oil, gas, and water separation and treatment equipment. Support of a single exploration and development operation in the central California offshore would require at least one supply vessel, one crew boat, and one helicopter. The crew boat would also function as a standby boat and would transport small supplies to the platform. The helicopter would be used for routine transportation of drilling crews and small supplies.

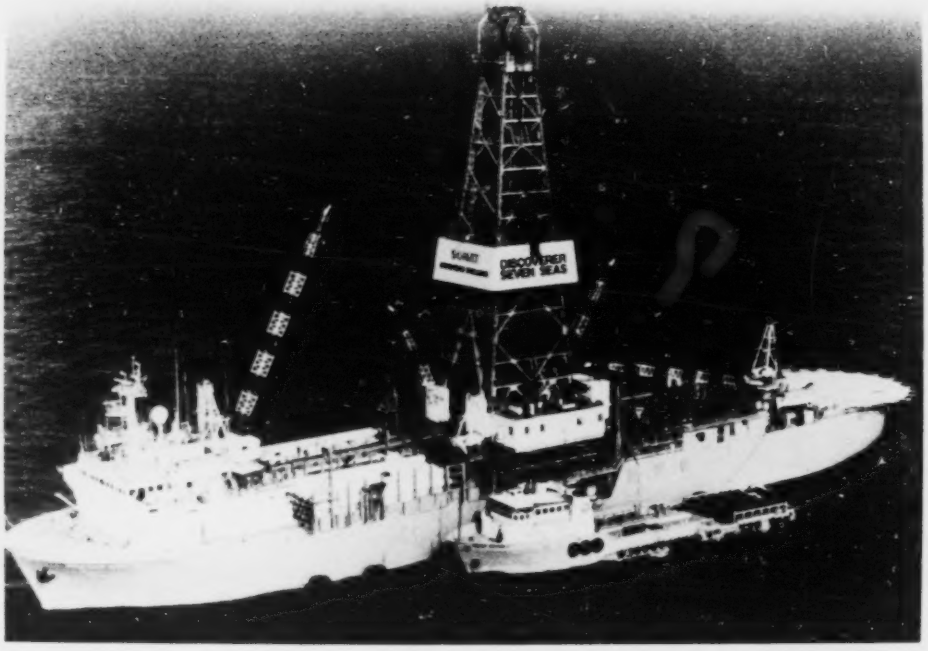

Photo credit: Shell Oil

Deepwater drillship "Discover Seven Seas" which drilled at record water depths in the Mid-Atlantic during 1983-84.

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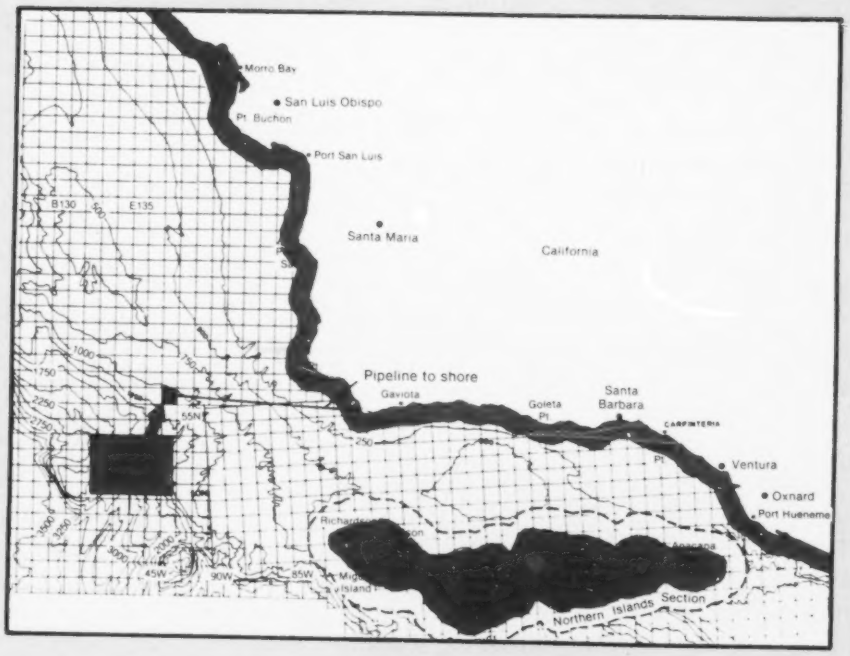

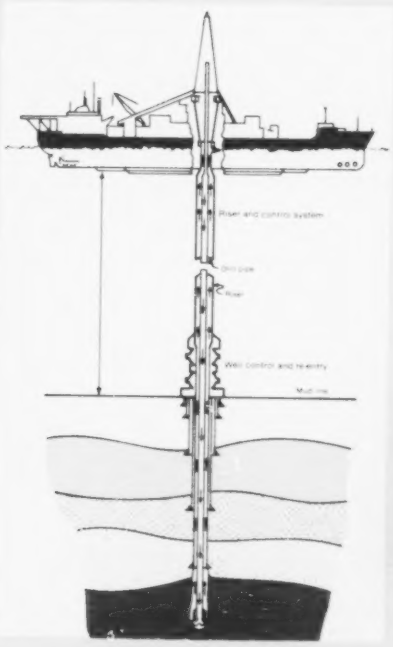

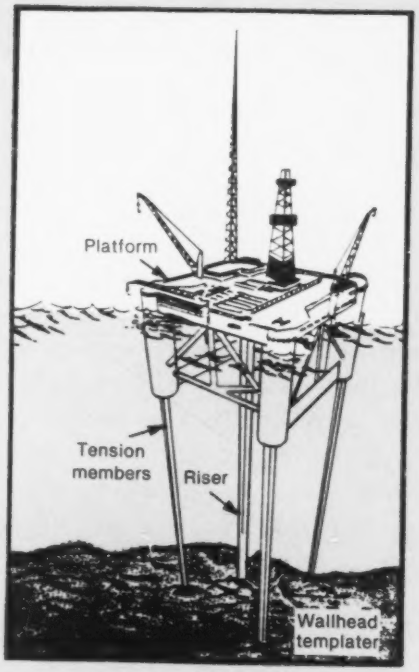

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Nearly all offshore fields discovered thus far have been developed using fixed-leg production platforms. This trend has been an extension of scaled-up shallow-water technology. Technically, fixed-leg platforms can probably be designed for water depths of 1,575 feet or more. However, the immense amounts of steel required, coupled with the cost of fabrication and installation, may limit the economic application of fixed-leg platforms to water depths of about 1,480 feet.

It is reasonable to expect that in a few years, several types of production systems will be designed and built for water depths of 1,640 to 2,500 feet. Advanced conceptual design and some component testing are underway for compliant and floating platforms, subsea wellheads, and submerged production systems for these water depths. However, there has been limited effort to develop site-specific engineered solutions for use in deeper waters because of the lack of commercial discoveries.

Industry experts generally agree that current technology may be extended to about 8,000 feet without the need for major breakthroughs. Existing technologies which are particularly promising for deepwater include buoyant towers, tension leg platforms, and subsea production units. All but the subsea production units are generically referred to as "compliant structures," which flex and give way under wind, wave, and current forces.

A number of technologies related to the production system are critical to deepwater development. These include unique structures design, materials development, and ocean floor foundation engineering. Innovative installation, maintenance, and repair techniques are important for structures, risers, and deepwater pipelines. Drilling, well control, and well completion are also important to deepwater development. Human diving capability is currently limited to about 1,640 feet, although there have been experimental dives to 2,300 feet. Both one-atmosphere manned vehicles and remote-controlled unmanned vehicles will be increasingly used for construction, maintenance, monitoring, and repair of equipment. Deepwater pipeline systems will involve adaptation of conventional pipelaying techniques and new approaches to overcome problems of buckling caused by long unsupported span lengths, higher strain levels, and severe sea states.

OFFSHORE SAFETY

Special safety risks are present in oil and gas development in offshore frontier regions because of the harsh environments and remote locations. In general, the safety record of offshore operations appears equal to or better than the record of comparable onshore industries.

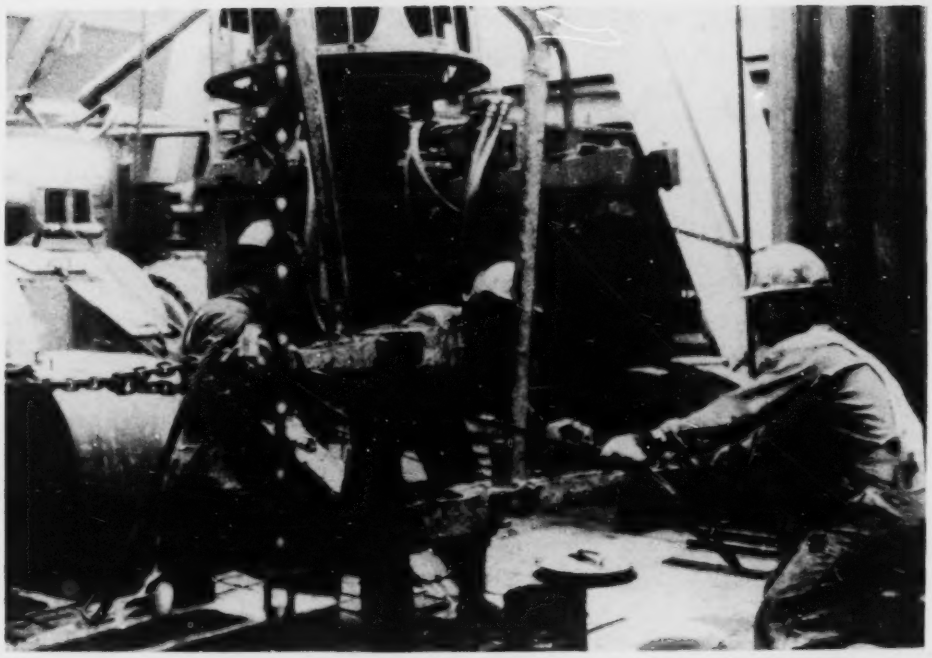


Photo credit: Peter Johnson, OTA

Roughnecks on the drilling rig floor at Shell's Seal Island discovery in the Beaufort Sea.

Still, there may be a need for new approaches to preventing work-related injuries and fatalities in coping with new hazards in the hostile Arctic and deepwater frontiers. The oil and gas industry has the primary responsibility for ensuring the safety of offshore operations and is governed by a complex system of regulations. Both the U.S. Coast Guard and MMS enforce regulations controlling aspects of workplace safety.

The possibility of catastrophic rig accidents is the greatest concern in offshore frontier areas. Such incidents have occurred in the past because of storms, structural failures, and capsizings. Other fatalities have been caused by well blowouts, explosions, and fires. Currently, there is no regulatory requirement for the submission of integrated safety plans which address technical, managerial, and other aspects of the safety of offshore operations. In addition, insufficient funding may result in inadequate rig safety inspections and monitoring efforts. Comprehensive safety plans, increased regularity of government monitoring efforts, and improved inspection techniques to match the increasing complexity and sophistication of offshore facilities may be needed.

Environmental conditions in frontier regions also present unique problems in evacuating personnel from rigs and platforms. Conventional lifeboats and rafts cannot be used on ice or in remote locations.

Free-falling boats, air-cushioned vehicles, special aircraft or helicopters, and icebreaking ships may be needed to evacuate personnel from rigs. It has been proposed that appropriate standby vessels be required by law to be stationed near offshore facilities. The adequacy of evacuation measures could be assured by evacuation performance requirements, regular inspections, and evaluation of evacuation drills.

Since offshore accidents are most frequently caused by human errors rather than by equipment failures, there are limits to safety improvements possible through purely technical means. To achieve some improvement in human activity, responsibility for safety could be delineated more clearly and better defined chains of command could be established. More extensive and improved work force training also may be necessary for operations in hostile frontier regions.

There is currently no single comprehensive source of statistics on offshore injury and fatality rates. The lack of data makes it difficult to evaluate the level of safety achieved by the offshore oil and gas industry or to assess the effects of safety regulations and equipment on the industry's safety performance. Improved population and injury data collection systems, greater consistency among data sources, and centralization of data collection and analysis in a single government agency could aid in evaluating the effectiveness of safety measures. Offshore safety data systems could be improved to include comprehensive event and exposure data; to relate events to specific employers, locations, operations, and equipment; to calculate frequency and severity rates and analyze trends; and to permit monitoring of the relative safety performance of owners and employers, locations, and activities.

FEDERAL OFFSHORE SERVICES

The Federal Government provides a variety of services and information that bear on the development and protection of offshore resources. Government services most useful to the offshore oil and gas industry are those that support maritime operations, including research and development, weather information, navigation services, and icebreaking. The adequacy of these services for large-scale oil and gas development in offshore frontier areas, particularly the Arctic, is in question. There is also debate regarding the appropriate division of costs and responsibilities between the government and the private sector in the provision of offshore services.

The most significant government research and development program is the MMS Technology Assessment and Research Program, which focuses on the evaluation of offshore technologies with regard to safe

Photo credit: Gulf Oil Corp.

A great deal must be known about ice forces to allow safe Arctic operations.

operation and pollution avoidance. This program, which has almost been eliminated in past budget cuts, is the primary research activity supporting Federal regulatory efforts and deserves continued support. In 1984, Congress enacted the Arctic Research and Policy Act to facilitate the coordination of Arctic research. However, this Act does not contain authority for the appropriation of additional funds, and budget support for Arctic research must come from existing programs.

Federal programs providing weather and ice information and navigational services are generally considered marginal for increased industry activities in offshore frontier regions, but at the same time are targeted for budget cuts. The Administration has proposed shifting the responsibility for weather satellite services and coastal and bathymetric charting to the private sector. In addition, there are plans to phase out existing radionavigation systems and replace them with a single satellite system—the Global Positioning System (GPS). Despite the dependence of the oil and gas industry on accurate ice information, there are limitations on sensing equipment and significant voids in satellite coverage for a major part of the Arctic.

The proper role of the government in the provision of icebreaking services is also in question. Icebreaking will be essential to maintaining shipping lanes and drillship sites, protecting drilling operations from drifting ice, and aiding supply and logistics operations, oil spill response, and search and rescue. However, the Coast Guard, which would normally provide these services, has no plans for an Arctic facility. The closest Coast Guard facility to Point Barrow, Alaska, is now 400 miles to the south. While the Coast Guard will continue to meet its overall icebreaking obligations to the extent allowed by the budget, additional capacity may not be available to serve the expanding needs of the offshore petroleum industry.

ECONOMIC FACTORS

Exploration and development of oil and gas resources in Arctic and deepwater frontiers will result only if the promise of economic returns outweighs the associated high risks and costs. In general, higher costs and longer lead-times to production lower the profit margins of resource development in offshore frontier areas. As a result, the sensitivity of project economics to changes in various economic factors—e.g., costs, prices, and government payments—is higher in frontier areas than in mature producing regions such as the shallow areas of the Gulf of Mexico. The leasing and payment provisions of the OCS Lands Act Amendments of 1978 were based largely on experience gained from oil and

gas leasing in State submerged lands and the Federal areas of the Gulf of Mexico and California.

OTA used a computer simulation model to analyze the economic attractiveness of oil and gas development under deepwater and Arctic conditions and to assess the implications of government policies. Cash flow profiles were developed for the four technology scenarios in the Navarin Basin, Harrison Bay, Norton Basin, and California deepwater, as well as for a more conventional project in the Gulf of Mexico.

Extremely large oil and gas discoveries are needed to offset the high costs and long timeframes of development in offshore frontier areas. While a 40- to 50-million-barrel field may be highly profitable in the shallow-water areas of the Gulf of Mexico, some economic projects in the Alaskan offshore may depend on finding 1 to 2 billion barrels or more of recoverable reserves. Fields of this magnitude are called "elephants" by the industry and are extremely limited.

The OTA computer simulation indicated that government lease and tax payments affect the profitability of offshore fields differently in frontier areas than in other leasing areas. Fixed royalties tend to overtax small fields and remove the economic incentive for the development of resources. Bidding systems based on alternative types of lease payments may reduce the financial risks associated with frontier-area fields and provide greater incentive to the development of marginal resources.

In general, the profitability of oil and gas development in deepwater and Arctic regions will be affected by increases or decreases in real oil and gas prices. In the Alaskan region, the availability of economic market outlets for oil and gas—from the export of Alaskan oil and the development of processing and transportation systems for Alaskan natural gas—could improve the economic profile of offshore fields.

FEDERAL LEASING POLICIES

In the 1980s, the Department of the Interior accelerated the rate and extent of offshore leasing as a means of hastening exploration and development of energy resources. Secretary James Watt initiated a system of "area-wide leasing," which expanded the offshore acreage considered for each lease sale. Approximately 1 billion acres of offshore land was to be offered in a 5-year period. The number of lease sales to be held each year was increased, and the focus was on leasing in deepwater and Arctic frontier areas. However, the actual pace of offshore leasing in this period was constrained by opposition and conflicts. **Resolution of the issues surrounding area-wide leasing could**

allow the new 5-year leasing program (1986-91) to proceed more smoothly.

A modified area-wide leasing system or what is termed the "focused" approach is intended to concentrate leasing in prospective areas in the proposed 1986-91 leasing schedule. In 1982, the Department of the Interior identified 179 million acres of offshore lands as containing geological structures capable of accumulating oil and gas. MMS has recently identified 522 million acres with the potential for hydrocarbon formation surrounding these structures. In contrast to the 1 billion acres to be offered under the original area-wide leasing system, the focused leasing system will most likely target offerings on the half of that acreage believed to have oil and gas potential.

A number of new features have also been added to the 1986-91 leasing schedule: earlier consultation with States, environmental groups, and the industry on areas to be included in lease sales; an added information-gathering step to determine industry interest in specific frontier-area sales; annual supplemental sales of development, drainage, and previously rejected acreage; and provisions to accelerate certain lease sales if warranted by economic conditions or new geologic data. During the 5-year period, a total of 43 sales are scheduled in 22 planning areas, with annual lease sales in the prospective Central and Western Gulf of Mexico planning areas and one sale every 3 years in other planning areas (see center box).

Challenges to the leasing program have been based primarily on the adequacy of environmental information to support lease sale decisions. Other litigation has stemmed from disagreements between coastal States and the Federal Government over requirements that Federal offshore actions be consistent with State coastal zone management programs. Congress imposed moratoria on leasing in some areas, largely as a result of Federal-State disputes on the division of escrow money from jointly owned tracts, the failure to devise a mutually acceptable revenue-sharing formula, and coastal zone management issues.

The extent of offshore acreage offered for lease has also been constrained by military deferrals of areas for fleet operations, submarine transit lanes, missile flights, aircraft testing, underwater listening posts, and other uses. As offshore oil and gas activities have expanded into frontier regions, a possible incompatibility between military and energy development uses in some areas of the ocean has become more obvious. Continuing deferrals may result in permanent withdrawals of OCS lands for military reservations. Such reservations could remove a significant amount of potentially productive acreage from oil and gas development. Currently, there is some confusion as to who has final authority for withdrawing acreage from oil and gas development—the Depart-

ment of the Interior, Department of Defense, or Congress. If uncertainty in the frontier-area leasing process is to be reduced, this issue as well as questions regarding U.S. international boundaries in several frontier regions and the exact delimitation of the U.S. Outer Continental Shelf eventually should be resolved.

In order to provide the necessary incentives for exploration and development in offshore frontier areas, it may be desirable to implement new leasing approaches or modify lease terms and conditions. There is general agreement on the need for longer lease terms for offshore deepwater and Arctic areas in view of the much longer period of time needed to explore and develop resources under hostile operating conditions. As leasing in offshore frontier areas has increased, more tracts have been offered and leased with 10-year rather than 5-year lease terms. However, specific criteria may be needed for extending lease terms. In addition, there should perhaps be a requirement for submission of exploration plans within a specified timeframe to ensure diligent operations.

There is less agreement on the type of bidding systems appropriate to offshore frontier areas. The Department of the Interior prefers the traditional cash bonus bid with a fixed royalty system which has gained general acceptance from industry and is easy to administer. However, bidding variables other than the cash bonus and lease payments other than fixed royalties may be more suited to the economics and risks of frontier areas. Other countries leasing in frontier areas generally have used a more flexible work commitment system in conjunction with larger lease areas and longer lease terms. After discovery of oil or gas, government payments may be based on profits, on productivity of the tracts, or other variables which take into account the costs and risks of development. More analysis and testing are needed before any attempts at implementation of these systems on a broad basis.

ENVIRONMENTAL CONSIDERATIONS

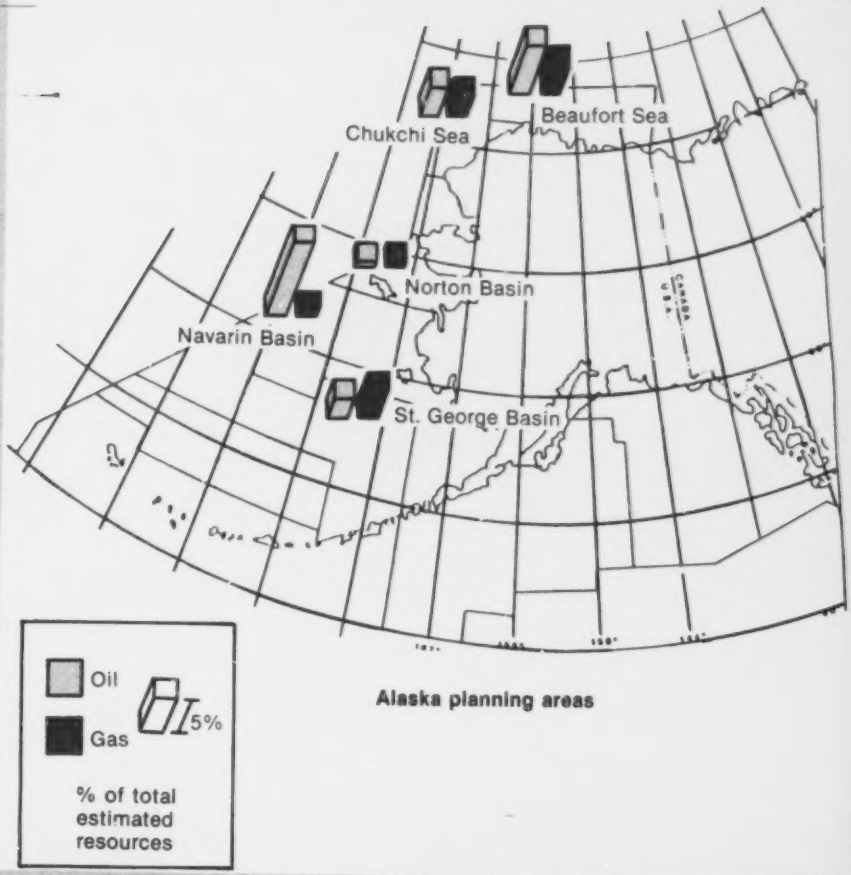
The development of offshore oil and gas resources and protection of the environment are potentially conflicting objectives and the subject of continuing debate. Nevertheless, the OCS Lands Act Amendments of 1978 require that energy and environmental policy goals be balanced in offshore development. Other Federal laws provide additional environmental safeguards. Major environmental considerations related to the development of Arctic and deepwater areas include trends in the Department of the Interior's Environmental Studies Program, the status of the endangered bowhead whale and other marine mammals, and the adequacy of oil spill containment and cleanup techniques.

Resource Distribution by

Proposed 5-year OCS lea

Western Gulf	July 1986
Supplemental 1	Aug 1986
Navarin Basin	Sept 1986
Beaufort Sea	Dec 1986
Southern California	Apr 1987
Central Gulf	Apr 1987
Chukchi Sea	May 1987
Western Gulf	Aug 1987
Supplemental 2	Aug 1987
North Atlantic	Nov 1987
Shumagin	Dec 1987
Northern California	Dec 1987
Central Gulf	Feb 1988
Gulf of Alaska	Mar 1988
Eastern Gulf	May 1988

St. George Basin	
Western Gulf	
Supplemental 3	
Mid-Atlantic	
North Aleutian Basin	
Central Gulf	
Norton Basin	
Central California	
South Atlantic	
Western Gulf	
Supplemental 4	
Navarin Basin	
Beaufort Sea	
Central Gulf	
Chukchi Sea	



Alaska planning areas

SOURCE: Minerals Management Service, *Estimates of Undiscovered Oil and Gas Resources for the Cu*

OCS Planning Areas (1985)

ısing schedule (7/86-6/91)

.....Jul 1988	Southern California .....Apr 1990
.....Aug 1988	Cook Inlet .....June 1990
.....Aug 1988	Western Gulf .....Aug 1990
.....Oct 1988	Supplemental 5 .....Aug 1990
.....Dec 1988	Shumagin .....Sept 1990
.....Feb 1989	North Atlantic .....Oct 1990
.....Mar 1989	Northern California .....Dec 1990
.....May 1989	Kodiak .....Jan 1991
.....Jul 1989	Central Gulf .....Feb 1991
.....Aug 1989	St. George Basin .....Apr 1991
.....Aug 1989	Washington-Oregon .....Apr 1991
.....Sept 1989	Eastern Gulf .....May 1991
.....Dec 1989	Hope Basin .....June 1991
.....Feb 1990	
.....Mar 1990	

Lower 48 planning areas

...Continental Shelf (Personal correspondence, Feb. 4, 1985).

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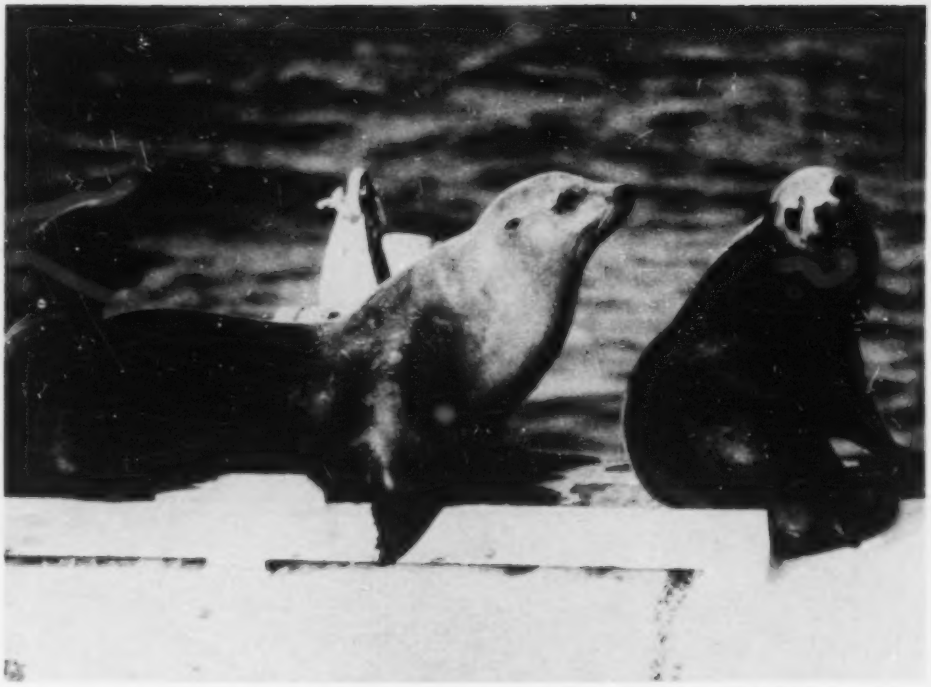

Photo credit: American Petroleum Institute

Offshore energy production must be balanced with protection of seals and other wildlife.

The OCS Lands Act directs the Department of the Interior to systematically study the environmental components that may be affected by offshore development. The MMS Environmental Studies Program includes research on the distribution and population dynamics of marine species, the fate and effect of oil spills, and general ecosystem processes. Overall funding for the Environmental Studies Program has been decreasing at a nearly constant rate since 1978. MMS maintains that a great deal has been learned about the offshore environment in the past 10 years of the program, and that substantial additional research may not now be warranted. However, the projected pace of leasing in the relatively unknown deepwater and Arctic regions and the need to monitor and regulate post-lease exploration and development activities may require more rather than less study of environmental effects.

Although many species of fish, marine mammals, and birds may be affected by oil and gas development, bowhead whales have received the most attention in recent years. Controversies surrounding the bowhead whale demonstrate the complexity of managing and protecting marine animals. Bowhead whales, which are classified as an endangered species, could be adversely affected by offshore oil and gas

Photo credit: National Marine Fisheries Service

The endangered bowhead whale is important to the Inuit culture.

operations in the Arctic. Bowhead whales hold special meaning for the native Alaskan Inuit and Yupik people, and they serve as a supplementary food source for native people throughout much of the Arctic region. In addition, whales are involved in the politics of the international conservation movement and come under the scrutiny of the International Whaling Commission.

In comparison to funds spent on studying other endangered species, a large proportion of available funds has been spent on bowhead whale research. Despite the large sums of money that have been expended, most scientists are reluctant to make unqualified statements concerning population, reproduction, or the effects of oil and noise on the animals. Four major areas are targeted for more research: 1) bowhead whale population estimates, 2) the effects of noise on whales, 3) the long-term cumulative effects of industrial activities on whales, and 4) identification of critical habitats for bowheads.

Although the risk of catastrophic oil spills from offshore operations is believed to be low, effective containment and cleanup measures are essential in light of the potential harmful effects of any such spill. The offshore oil and gas industry is genuinely concerned and has diligently prepared for dealing with the eventuality of oil spills. Industry has in-

vested large amounts of funds and effort in engineering technology to prevent blowouts and other catastrophic rig accidents. Considerable costs for cleanup and damage claims could be associated with a large spill. Some claim, however, that there is little market incentive for developing oil spill countermeasures compared to spill avoidance.

For the most part, oil spill containment and cleanup technology has been developed for spills in nearshore and temperate regions. It may not be suitable for use under the extreme conditions of deepwater and the Arctic. Arctic oil spill countermeasures may be complicated by extremely cold temperatures, the presence of ice, long periods of darkness, intense storms, and lack of transportation and storage facilities in most areas. In deepwater areas, high sea-states may be encountered, and greater distances from shore may create logistical problems for oil spill cleanup. To date, it has not been demonstrated in a real situation that industry will be able to use effectively the existing oil spill equipment and countermeasure strategies in hostile environments.

ISSUES AND OPTIONS

Little is known about the actual resource potential of the offshore lands of the United States. Experts believe that major new oil and gas supplies may be located in the Arctic and deepwater frontiers. The country will need this oil and gas to fill energy requirements at the end of the century—a mere 15 years away. The history of petroleum exploration suggests that large fields are generally discovered early in the exploration cycle. Even if major resource discoveries are made by the end of the next 5-year leasing program in 1991, the Nation will still have serious decisions to make about its energy future. The offshore oil and gas industry may need incentives to reenter the frontier areas for a "second-round" of exploration of the promising but less-prolific oil and gas prospects.

OTA has identified policy options for expediting exploration and development of oil and gas in deepwater and Arctic offshore regions and for providing additional incentives to the industry. OTA has also outlined options for protecting environmental values and increasing offshore safety in conjunction with exploration and development activities. These issues and options should be considered by Congress in the review of the next 5-year leasing program (1986-91), which will place emphasis on leasing in offshore frontier areas.

Energy Planning and Offshore Resources

The goal of the offshore leasing program is to increase the Nation's energy supply, thereby reducing dependence on oil imports. The offshore frontier areas are believed to have the greatest potential for major new domestic oil and gas discoveries that will allow the Nation to accomplish that goal. In the next few years, most of the remaining prospective areas of the offshore frontier regions will be considered for leasing. Substantial exploration has already occurred in some offshore frontier areas, such as the Gulf of Alaska and Atlantic regions. However, except in the Gulf of Mexico and California nearshore areas, exploration thus far has added very little to proven reserves. Accurate knowledge of the resource potential of the Nation's offshore areas is critical to overall energy planning and to making decisions about the offshore leasing program and alternative energy programs. In order to effectively plan for future energy needs, the Nation may need to reevaluate the role and resource potential of offshore areas when the findings of exploratory drilling in offshore frontiers are available.

OPTIONS FOR CONGRESS	ACTION REQUIRED
1. Reassess available information about the resources of the OCS with regard to the potential of offshore oil and gas in supplementing the Nation's future energy supplies in the context of National Energy Planning.	Establish a congressional commission or request an existing body (e.g., National Research Council, National Petroleum Council) to reassess the role of offshore oil and gas in the Nation's energy future at some point in the next 5-year leasing schedule.

Area-wide Leasing

Exploration and development of oil and gas resources in offshore frontier areas can be encouraged by more rapid and efficient leasing of offshore acreage. The system of area-wide leasing initiated by the Department of the Interior in 1983 has increased the pace of leasing with the hope of early identification of resources. Area-wide leasing permits the industry to select from among the full range of available tracts in deepwater and Arctic regions and to explore those of greatest resource potential. However, the greater size and faster pace of lease offerings under the area-wide system may reduce the detailed consideration of environmental concerns, competing land uses, and State and

local views in the leasing process. A return to the previous tract nomination system could allow for greater outside input into the leasing process, but may slow determination of the resource potential of offshore frontier areas.

OPTIONS FOR CONGRESS	ACTION REQUIRED
1. Allow the Secretary of the Interior to determine the size of lease offerings in offshore frontier areas.	No action required by Congress.
2. Direct the Secretary of the Interior to use a tract nomination system for lease offerings in offshore frontier areas.	Amendment to OCS Lands Act or congressional directive through the appropriations process.

Military Use Conflicts

As exploration and development have expanded to offshore frontier regions, there has been increasing conflict between oil and gas activities and military uses of offshore areas. An estimated 40 to 55 million acres of offshore land are restricted from oil and gas development for military and national security purposes, and as much as 75 million additional acres are affected by restrictions on the density of oil and gas operations. Deferrals and exclusions of lease tracts for military reasons are now negotiated by the Department of the Interior and the Department of Defense. Past disagreements on offshore land uses have prompted a review of this procedure and have led to a new memorandum of understanding between the agencies. While the OCS Lands Act gives authority for withdrawal of offshore acreage for national defense purposes to the Secretary of Defense, the Withdrawal of Lands for Defense Purposes Act reserves this authority for Congress. Continuing confusion over who has final authority to withdraw offshore acreage adds uncertainty to the leasing process and may delay exploration in offshore frontier areas. A procedure is needed which resolves the conflicting authorities and adequately balances energy and military uses of offshore lands.

OPTIONS FOR CONGRESS	ACTION REQUIRED
1. Allow Secretary of the Interior and the Secretary of Defense to continue negotiating military withdrawals of OCS acreage.	No action required by Congress.

2. Delegate authority for military withdrawal of OCS acreage to one department.	Amendment to OCS Lands Act and/or amendment to Withdrawal of Lands for Defense Purposes Act.
3. Reserve authority for military withdrawal of OCS acreage to Congress.	Amendment to OCS Lands Act.

Disputed International Boundaries

Contested international boundaries eventually may contribute to delays in oil and gas exploration. There are unresolved disputes between the United States and other countries in several offshore frontier regions, including those with the Soviet Union in the Bering Sea and with Canada in the Beaufort Sea. A dispute between the United States and Canada over Georges Bank was recently arbitrated by the International Court of Justice, but important bilateral management issues are yet to be worked out. In addition, the outer boundary of the extensive U.S. continental shelf has not been delimited, and uncertain jurisdiction in the central Gulf of Mexico may eventually cause tension between the United States, Mexico, and possibly Cuba. Although there is no immediate need to resolve contested boundaries, such disputes could be settled through bilateral negotiation, arbitration, or mediation. Arrangements could be made for joint exploration and/or development of contested areas by the parties to the dispute. Contested offshore areas could also be withdrawn from oil and gas development pending settlement of disputes. Resolution of offshore boundary questions would help reduce international tensions and allow exploration and development of frontier areas to proceed in an orderly manner.

OPTIONS FOR CONGRESS	ACTION REQUIRED
1. Allow arbitration by the International Court of Justice to resolve boundary disputes.	Congressional directive to Department of State to negotiate arbitration agreements with other countries.
2. Establish an interim regime for exploration and/or development of disputed offshore areas.	Congressional directive to Department of State to negotiate appropriate agreements.
3. Create buffer zones in disputed areas where no oil or gas development would take place.	Congressional directive to Department of State to negotiate appropriate agreements.

Lease Terms[1]

Longer lease terms may be needed in offshore frontier areas to allow sufficient time for exploration and identification of resources. The standard 5-year lease term for offshore tracts has been increased to 10 years for many tracts in deepwater and Arctic areas under the authority provided to the Secretary of the Interior in the OCS Lands Act. However, the lack of set criteria for 10-year lease terms adds uncertainty to the offshore leasing process in Arctic and deepwater frontier areas. In addition, 10-year lease terms in deepwater now are provided only for tracts in water deeper than 900 meters or 2,950 feet. An established policy on 10-year lease terms and a more realistic deepwater marker may be needed. The Department of the Interior has proposed automatic 10-year lease terms for all tracts in water deeper than 400 meters or 1,320 feet. Currently, companies with 10-year leases have no set deadline for the submission of exploration plans and may hold a lease for 8 or 9 years before filing a statement of intention to explore. In conjunction with a longer lease term policy, the Department of the Interior may need to ensure diligent exploration in frontier areas by requiring submission of exploration plans at a specific time in the lease term (e.g., fifth or sixth year).

OPTIONS FOR CONGRESS	ACTION REQUIRED
1. Establish automatic 10-year lease terms for tracts in water depths greater than 400 meters and for selected Arctic regions.	Congressional directive to Department of the Interior through the appropriations process.
2. Establish automatic 10-year lease terms for selected offshore frontier areas and include provisions for submission of exploration plans within a specific time period.	Congressional directive to Department of the Interior through the appropriations process.

Alternative Bidding Systems

The United States has traditionally allocated offshore tracts on the basis of the highest cash bonus bid with a fixed royalty payment. The OCS Lands Act Amendments of 1978 mandated testing of several alternative bidding systems. However, after testing, the Department of the Interior prefers the traditional system. This bidding system is easy to

[1]MMS has extended lease terms for deepwater tracts (*Federal Register*, Apr. 3, 1985). Tracts in water depths between 400 and 900 meters will have 8-year terms, and tracts in waters deeper than 900 meters will have 10-year terms. To ensure exploration diligence, exploration drilling is required during the first 5 years.

administer, has promoted efficient exploration and development of offshore tracts in conventional leasing areas, and has been accepted by both government and industry. However, there may be disadvantages in using this system to allocate offshore frontier tracts. The requirement for upfront cash bonus payments may be a deterrent to continued exploration of frontier areas, because these areas involve greater uncertainty and far higher costs. Alternative arrangements such as work commitments may be needed to sustain activities in high-risk deepwater and Arctic regions. In addition, because of low profit margins in frontier areas, fixed royalties may overtax small fields and lead to nondevelopment of resources. Bidding systems with other types of lease payments, such as sliding scale royalties, net profit shares, or even zero royalties, may provide more incentives to marginal resource development. Effective implementation of alternative bidding systems, however, will require additional experimentation, analysis of costs and benefits, and adjustments in other lease conditions such as the size of the lease tracts.

OPTIONS FOR CONGRESS	ACTION REQUIRED
1. Allow the Secretary of the Interior to select the bidding system to be used in offshore frontier areas.	No action required by Congress.
2. Direct the Secretary of the Interior to continue testing alternative bidding systems in offshore frontier areas.	Amendment to OCS Lands Act.

Alaskan Oil Export Ban[2]

Removing the ban on exporting oil produced in offshore Alaskan areas could provide an added economic incentive to developing offshore resources in the Arctic. In the 1970s, concern about the Nation's increasing oil import dependence prompted Congress to place restrictions on the export of oil produced on Alaska's North Slope and in offshore areas. About half of the oil produced on the North Slope is now shipped to Gulf of Mexico and Atlantic Coast refining centers. Exporting oil to closer markets in Japan and other Asian countries could reduce transportation costs and increase the profits of producing Alaskan oil. The increased profit margins on offshore fields could improve the prospects for developing marginal resources in Alaskan offshore areas. However, removing the export ban could have economic and national security costs as a result of increased dependence on imported oil and

[2]The House of Representative passed a 4-year extension of the Export Administration Act, which contains restricitons on the export of Alaskan oil, on Apr. 16, 1985.

adverse effects on domestic shipping which heavily depends on the Alaskan tanker trade. In addition, it is not certain that export markets in Japan could be established.

OPTIONS FOR CONGRESS	ACTION REQUIRED
1. Remove restrictions on exporting oil produced in Arctic offshore regions.	Amendment to Export Administration Act.
2. Evaluate advantages and disadvantages of exporting Alaskan oil, with reference to economics of Alaskan offshore oil production and market development.	Establish an Alaskan Oil Export Commission to make recommendations on exporting Alaskan oil.

Environmental Information

The Environmental Studies Program administered by the Minerals Management Service is the major research program on the effects of oil and gas development on offshore environments. This information is used in preparing Environmental Impact Statements and as an aid to the Secretary of the Interior in weighing the costs and benefits of offshore development. The Environmental Studies Program is changing its emphasis in the Alaskan region from acquiring pre-lease information to acquiring post-lease data needed for management of oil and gas activities. Funding for the program, however, has been decreased and led to a reduction in both pre-lease and post-lease studies. Proportionally, the decrease in funds for the Alaskan regions has been greater than that for temperate coastal areas. In general, decreases in the Environmental Studies Program budget may not be justified in view of the relative lack of understanding of Arctic and deepwater marine environments, the projected pace of leasing in frontier areas, and the continuing need to monitor offshore oil and gas activities.

OPTIONS FOR CONGRESS	ACTION REQUIRED
1. Allow Secretary of the Interior to determine the allocation of research funds for environmental studies of different offshore regions.	No action required by Congress.
2. Review funding levels for environmental studies in offshore frontier regions in light of new 5-year leasing schedule.	Conduct congressional hearings on Environmental Studies Program and oversight review. Appropriate additional funds if found necessary.

Oil Spills

The offshore oil and gas industry has a good record of preventing oil spills. However, it has little experience in containing and cleaning up oil spills in offshore frontier environments, where there is now little oil production. Most current technology was developed for nearshore and inshore areas and may not be suited to frontier areas characterized by severe wind and waves, ice, extended periods of darkness, and/or low temperatures. Industry has directed its investments primarily to oil spill prevention rather than containment and cleanup, and government funding for oil spill technology research has been low. The OHMSETT (Oil and Hazardous Material Simulated Environmental Test Tank) Interagency Technical Committee has conducted limited testing of Arctic oil spill countermeasures technology, but budget constraints may reduce future testing. Government evaluation and publication of oil spill equipment test results could provide incentives to industry to improve countermeasures technology. Certain performance requirements might also encourage the industry to develop new technology and engineering approaches for dealing with oil spills.

OPTIONS FOR CONGRESS	ACTION REQUIRED
1. Increase funding for research on oil spill countermeasures technology in offshore frontier areas.	Increased appropriations to OHMSETT, MMS, EPA, NOAA, and/or Coast Guard oil spill research programs.
2. Develop a program for oil spill equipment testing and publication of results.	Congressional directive to Department of the Interior through the appropriations process.
3. Establish performance standards for industry oil spill response capability.	Amendment to OCS Lands Act and/or congressional directive to Department of the Interior through the appropriations process.

Offshore Safety

The hostile operating conditions in deepwater and Arctic areas may require greater attention to personnel safety concerns during oil and gas activities. New technological approaches, management practices, and monitoring efforts may be needed to ensure high safety standards in offshore frontier regions. Improved Minerals Management Service and Coast Guard monitoring and inspection of offshore facilities could assure minimum safety standards and uniformity of safety conditions. Concern about possible catastrophic rig accidents has prompted pro-

posals for better evacuation procedures and techniques, regular evacuation drills, and requirements for standby vessels. Regulations concerning work force training and management safety practices may need to be reviewed and revised for frontier areas. In addition, it is difficult to evaluate the seriousness of offshore safety hazards because of incomplete and inconsistent safety data. Implementation of Federal safety responsibilities in offshore frontier areas will require adequate and accurate data in order to monitor safety performance and the effectiveness of safety initiatives.

OPTIONS FOR CONGRESS	ACTION REQUIRED
1. Increase funding for MMS and/or Coast Guard safety inspection programs in offshore frontier areas.	Congressional directive through the appropriations process.
2. Establish standards for evacuation procedures from fixed platforms and mobile drilling vessels in offshore frontier areas and periodically monitor emergency evacuation drills.	Congressional directive through the appropriations process or Amendment to OCS Lands Act.
3. Consolidate responsibility for collecting, analyzing, and reporting safety-related data in a single agency (MMS or Coast Guard).	Congressional directive through the appropriations process or Amendment to OCS Lands Act.

Coast Guard Programs

The capacity of the U.S. Coast Guard to effectively conduct its missions in Arctic regions is limited and will be increasingly inadequate as offshore oil and gas development proceeds. Due to the current lack of activities in northern Alaskan offshore areas, Coast Guard operations in Alaska are concentrated in the Gulf of Alaska, far to the south of the prospective Arctic oil areas in the Bering, Chukchi, and Beaufort Seas. The lack of an operational Coast Guard facility in the Arctic greatly impedes the agency's capabilities for search and rescue, vessel and platform safety inspection, law enforcement, maintenance of navigation, oil spill cleanup response, and icebreaking. Despite the potential for greater human safety and environmental risks in the region as a result of the increase in oil and gas activities, the Coast Guard currently has no plans for basing equipment and personnel in Arctic areas. However, studies of a potential Arctic facility are underway.

OPTIONS FOR CONGRESS	ACTION REQUIRED
1. Establish a Coast Guard base in the Arctic region.	Congressional directive through the authorization/appropriations process.

Ice Information

Arctic oil and gas operations depend on timely information about the location and movement of sea ice. Weather conditions and remoteness of facilities potentially make satellite imagery a very useful source of information on ice conditions. However, U.S. Arctic satellite-sensing capability is limited by the number of satellites and the capabilities of existing sensors. In addition, the usefulness of ice information obtained from satellites is reduced by the length of time needed for processing and delivery to users. Planned improvements in U.S. satellite systems will increase ice-related coverage of Arctic areas and contribute to the safety and efficiency of Arctic oil and gas development. Use of data from European and Canadian satellites could also assist offshore activities. However, there are uncertainties as to the timing and extent of improvements in U.S. satellites, the availability of information from foreign satellites, and the means for making satellite information available to the private sector. The Navy/NOAA Joint Ice Center, which has primary responsibility for processing and disseminating satellite ice data, could be upgraded to provide more timely operational data. In the absence of improved government ice data collection and distribution, the industry will have to place greater reliance on private sector ice information services.

OPTIONS FOR CONGRESS	ACTION REQUIRED
1. Upgrade U.S. satellite system to improve ice data for oil and gas operations.	Congressional directive through the appropriations process.
2. Increase government acquisition of ice information from foreign polar satellite systems.	Congressional directive through the appropriations process.
3. Expand ice information processing and dissemination by the Joint Ice Center.	Increased appropriations for the Navy/NOAA Joint Ice Center. Establish the Center permanently through authorizing legislation.

Government Information Services

Improved coordination and delivery of government information could facilitate operations in offshore frontier areas. Information and data relating to offshore oil and gas activities are now divided among several government agencies, including the Minerals Management Service, the National Oceanic and Atmospheric Administration, the Coast Guard, the Navy, and the Environmental Protection Agency. Users of offshore technical, environmental, and leasing information often find it difficult to identify agency contacts and sources of information within the government. The centralization of information services within a single agency has been proposed, but this would be difficult to implement in view of the contrasting responsibilities of the various agencies. NOAA has established a system of national ocean service centers, including an Anchorage center for the Arctic offshore area, which may provide a prototype for other agencies. These service centers act as regional clearinghouses for environmental and meteorological information gathered by NOAA. Other agencies, separately or in coordination with NOAA, could estabish similar regional clearinghouses for information distribution to the offshore oil and gas industry.

OPTIONS FOR CONGRESS	ACTION REQUIRED
1. Establish regional clearinghouses to collect and distribute government information relating to offshore oil and gas operations.	Congressional directive through the appropriations process.

NOTE: Copies of the full report "Oil and Gas Technologies for the Arctic and Deepwater" can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, GPO stock No. 052-003-00995-1.

Assessments in Progress as of May 1985

Technology and the American Economic Transition
Load Management and Generating Technologies for Electric Utilities in the 1990s
Western Surface Mine Reclamation
Technology and Structural Unemployment: Retraining Adult Displaced Workers
International Competition in the Service Industries
Coal Leasing Amendments of 1976
New Ballistic Missile Defense Technologies
Technology Transfer to China
Technology, Public Policy, and the Changing Structure of American Agriculture
Technologies To Maintain Biological Diversity
Integrated Renewable Resources Management for U.S. Insular Areas
Evaluation of Agent Orange Protocol
Status of Biomedical Research and Related Technology for Tropical Diseases
Medical Technology and Diagnosis-Related Groups: Evaluating Medicare's Prospective Payment System.
Technology and Indian Health Care: Effectiveness, Access, and Efficiency
Physicians and Medical Technology: Use, Cost, and Payment Methods
Technologies for Determining Mutation Frequencies in Human Beings
Alternatives to Animal Use in Testing, Research, and Education
Reproductive Health Hazards in the Workplace
Life-Sustaining Technologies and the Elderly
Disorders Causing Dementia
Information and Communication Technologies and the Office
Federal Government Information Technology: Congressional Oversight and Civil Liberties
Intellectual Property Rights in an Age of Electronics and Information
Technologies for Disposing of Waste in the Ocean
Hazardous Materials Transportation: Technology Issues
Science Policy Special Projects
Standardized Testing as a Measurement Tool for Federal Education Policy

(NOTE: For brief descriptions of these studies in progress—see OTA booklet on "Assessment Activities"—available from OTA's Publishing Office, 224-8996.)

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